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Response of Big-horn Sheep to the Ship I

Island Burn

RESPONSE OF BIGHORN SHEEP TO THE SHIP ISLAND BURN

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ABSTRACT

Vegetative and bighorn sheep population responses to the 11,000 acre Ship Island Burn of August, 1979, were reported. Bluebunch wheatgrass and Idaho fescue were initially reduced in vigor and subsequently increased over a three year period following the fire. Little greenbush resprouted but did not seed on burned sites. Scouler willow and shiny leaf ceanothus seeded readily on Douglas fir sites. Curlleaf mountain mahogany was killed by the fire and no evidence of resporuting or seedling establishment was noted over the three years following the fire. The bighorn sheep population did not shift habitat use patterns following the fire and showed no significant differences in numbers or lamb survival from adjacent populations during the three years following the fire.

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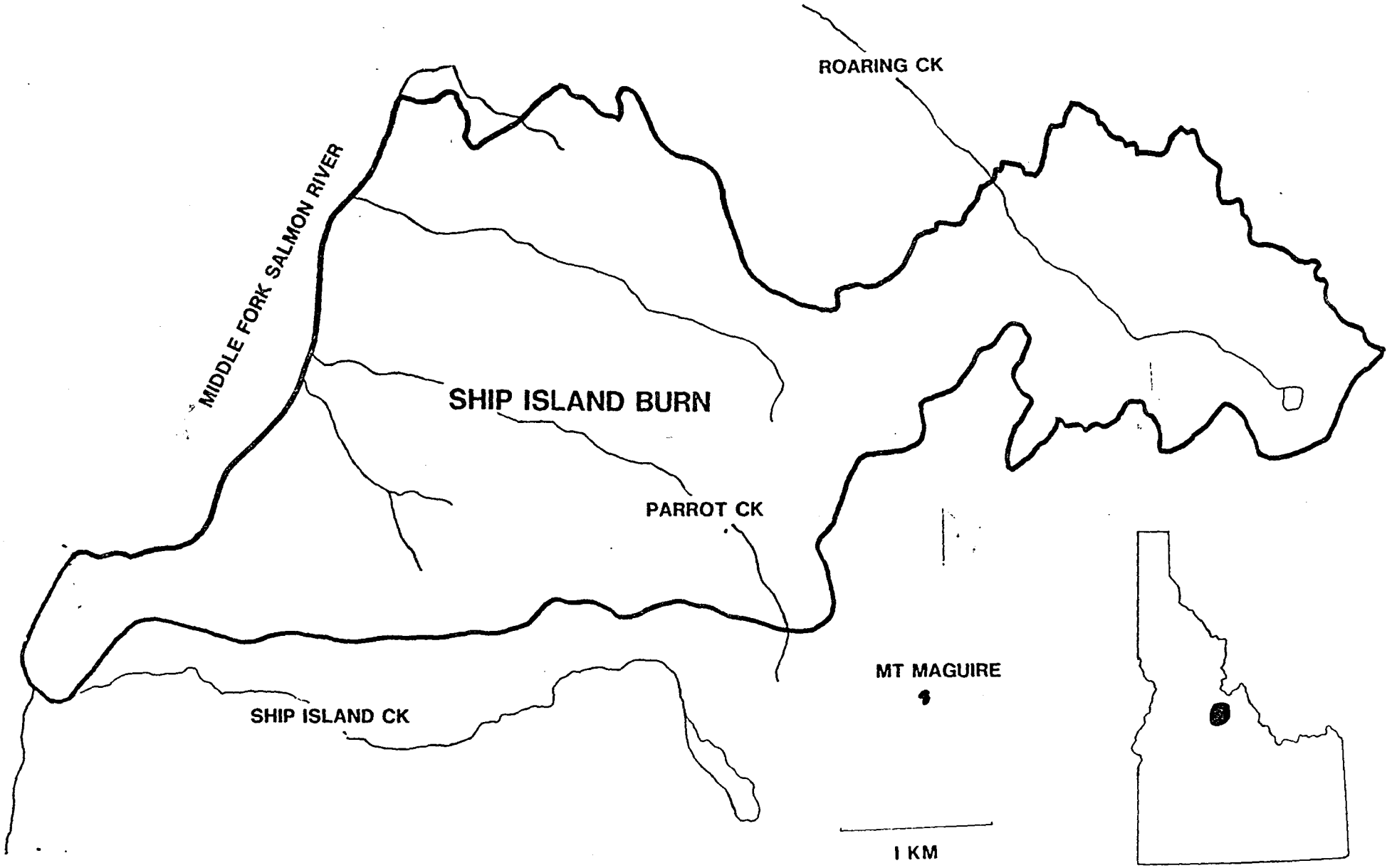
Bighorn sheep (Ovis canadensis) populations inhabiting the Salmon River drainage have lived in a region of high fire frequency. On the winter ranges adjacent to the Salmon River, the combination of steep slopes and abundant fuels make the area very susceptible to lightning-caused fire. Over 64 percent of the breakland has burned since 1900 (U.S. Forest Service 1973). Wright (1978) reported fire frequencies of between six and 19 years in Ponderosa pine communities, which appears to represent the Salmon River region well.

The Ship Island Fire of August, 1979, burned an important bighorn range in the Middle Fork drainage. This burn covered approximately 11,000 acres from the riverbank up to the heads of three drainages (Fig. 1). An average of 83 bighorn have been found in the area during animal surveys by helicopter (Hickey, personal comm. 1983).

Plans to allow fires to burn at more natural frequencies within the Frank Church River of No Return Wilderness (FCRNR) will be developed as part of the effort to retain and restore natural conditions. Bighorn sheep comprise an important component of the FCRNR and a knowledge of how populations will respond to fire is needed. The Ship Island Fire provided an important and unique opportunity to examine response of bighorn, and vegetation, to a wildfire in this region. Purposes of this investigation were to document population responses and vegetation response to the fire.

Both vegetation and bighorn occupy perhaps the most remote region in Idaho, where influence by humans, either indirectly as through grazing and logging or directly through exploitation of the population, was minimal. The major influence may have been fire suppression. Elk (Cervus elaphus)


ROARING CK
MIDDLE FORK SALMON RIVER
SHIP ISLAND BURN
PARROT CK
MT MAGUIRE
SHIP ISLAND CK
1 KM

and mule deer (Odocoileus hemionus) coexist in small numbers with bighorn in the area.

STUDY AREA

The Ship Island Burn is located on the west slope of the Bighorn Craigs Major portions of the Ship Island, Parrot, Tumble, and Roaring Creek drainages were burned. Over 85% of the area within the perimeter of the fire was burned. Elevations within the burn range from 975 m near the Middle Fork of the Salmon River up to 2926 m on Goat Mountain.

The average annual precipitation for the area is approximately 30 cm occurring primarily as snow. Snow accumulation on the bighorn sheep winter range reaches a maximum of 15-30 cm during January/February (Smith, 1954), and temperatures may drop to -30 °C in January. Summers are characteristically hot and dry, and temperatures may range to above 30 °C during August.

The soils in the area are well drained sandy soils of granitic origin. Depths are shallow, and granitic outcrops are common (Larson and Lovely 1972). The soil is highly erodable, typical of the Idaho Batholith.

Vegetation changes from grassland dominated by bluebunch wheatgrass (Agropyron spicatum) on lower, drier sites through an elevational gradient into spruce-fir (Picea engelmanni)/(Abies lasiocarpa) (Hironaka et al. 1983, Steele et al. 1981). Rocky outcrops may be dominated by a mountain mahogany (Cercocarpus ledifolius)/bluebunch wheatgrass habitat type. Little greenbush (Glossopetalon nevadense) may be common in some of these outcrops. Douglas fir (Pseudotsuga menziessi) dominated habitat types occur above the grassland and shrubland types. Common habitat types appear to be Douglas

fir/Idaho fescue (Festuca idahoensis), Douglas fir/Pinegrass (Calamagrostis rubescens), Douglas fir/mountain mahogany, Douglas fir/snowberry (Symphonicarpos albus) and Douglas fir/ninebark (Physocarpus malvaceus). Areas above the Douglas fir series are often dominated by lodgepole pine (Pinus contorta) and have understories dominated by grouse whortleberry (Vaccinium scoparium) or beargrass (Xerophyllum tenax), and belong to the spruce-fir series of habitat types. Bighorn winter primarily on the grassland, shrub, and drier Douglas fir sites.

METHODS

Vegetation was sampled during the summers of 1980, 1981, and 1982. Canopy coverage and frequency were estimated on each of 28 paired sites, burned and unburned, using 20 2 x 5 dm plots placed perpendicular to a 50-foot transect (Daubenmire, 1959). Two transects were established for each site.

Productivity of annual grasses, perennial grasses, annual forbs, perennial forbs, bluebunch wheatgrass (Agropyron spicatum), and Idaho fescue (Festuca idahoensis) was estimated in each 2 x 5 dm plot. Estimates were checked by clipping and weighing plants from ten plots to the nearest gram to determine green weight. Vegetation from the ten clipped plots was bagged and later weighed to the nearest gram after oven drying at 75 °C for 24 hours. All weights were converted to oven dried weights.

Seed stalk heights and diameters of basal clumps of 25 plants of bluebunch wheatgrass and Idaho fescue were measured to the nearest cm at each site.

Numbers of seedlings and rooted stems of woody plants were counted in ten 10 m^2 circular plots per sample site to determine densities of curlleaf mountain mahogany, little greenbush, scouler willow (Salix scouleriana), and shiny-leaf ceanothus (Ceanothus velutinus).

Twelve randomly located mountain mahogany and little greenbush plants were selected at each site to estimate canopy height, two canopy diameters, twig number, number of twigs browsed, length and basal diameter of current annual growth (10 twigs per plant). Statistical analysis of the vegetation data consisted of paired t tests and regular t tests.

Aerial surveys in fixed wing aircraft were used to determine bighorn sheep habitat use patterns. The flights were conducted from December through March during the three winters following the burn. Group size, location, elevation, aspect, cover type, and activity (if possible) were recorded for each group of bighorn.

Data from winter herd composition flights conducted by W. O. Hickey (Idaho Department of Fish and Game) from 1974 through 1984 were to determine trends in population that might be related to the burn. A comparison of population group size, and herd composition for burned and unburned areas was made. Habitat use patterns were determined using a chi-square analysis used in conjunction with the grid technique of Marcum and Loftsgaarden (1980).

RESULTS AND DISCUSSION

Table 1 lists location and some characteristics of the vegetation study sites by habitat type. A total of 16 paired and one unpaired transects was established. Little greenbush was associated with Wyoming

Table 1. Locations of vegetative studies in the habitat types on the Ship Island Study Area. *Indicates presence of little greenbush (Glne), curlleaf mountain mahogany (Cele), shinyleaf ceanothus (Ceve), Scouler willow (Sasc), bluebunch wheatgrass (Agsp) and Idaho fescue (Feid) on sites. Habitat types follow Steele et al. (1981) and Hironaka et al. (1983).

Habitat Type	Number Sites	Glne	Cele	Ceve	Sasc	Agsp	Feid
Mountain mahogany/ bluebunch wheatgrass	4		X			X	X
Douglas fir/Idaho fescue	4	X	X			X	X
Douglas fir/Idaho fescue	4					X	X
Mountain mahogany/ bluebunch wheatgrass	4	X	X			X	X
Douglas fir/ninebark	4						X
Douglas fir/pinegrass	4						X
Subalpine fir/grouse whortleberry	4						
Douglas fir/ninebark	1			X	X		
Big sagebrush/bluebunch wheatgrass	4	X				X	X

big sagebrush, curlleaf mountain mahogany, and Douglas fir on steep, rocky sites. Scouler willow and shiny-leaf ceanothus were found in the Douglas-fir/ninebark habitat types, suggestive of a recent fire history. Curlleaf mountain mahogany was found on rocky outcrops, but also in sparsely stocked stands of Douglas fir.

Herbaceous vegetation

Canopy coverage and frequency values of forbs, grasses, and coverage of bare ground, litter and rock for the three seasons of study are provided in Appendix I. As expected, the Ship Island Fire dramatically altered canopy coverage of important species the first season (Table 2). Bare ground and rock coverage was increased significantly on the burned sites while litter was significantly reduced.

Annual forbs, including Collinsia (Collinsia parviflora), tansymustard (Descurainia sp.), and threadleaf phacelia (Phacelia linearis) showed significant increases in canopy coverage on the burned sites. Collinsia, tansymustard, and phacelia all peaked in canopy coverage on burned sites the first growing season following the fire and maintained more canopy coverage on burned sites than on adjacent unburned sites throughout the three post-burn growing seasons.

Most of the perennial forbs showed less than a 1% change in canopy coverage as a result of the fire. Hooker balsamroot (Balsamorhiza hookeri), woods strawberry (Fragaria vesca), and groundsel (Senecio integerrimus) were notable exceptions that significantly decreased in canopy coverage on the burned sites. All three species had diminished coverage for three growing seasons after the fire.

Table 2. Comparison of changes in canopy coverage of herbaceous and vegetation on unburned and burned sites on the first year, between the first, second and between the growing seasons after the Ship Island Fire. * indicates differences were significant between burned and unburned, and between years at p = 0.05.

Species	Number Paired Plots	Percent mean difference 1980-81 Burned	1980-81 Unburn.	1980-82 Burned	1980-82 Unburn.	1980
Bare ground	14	5.29	2.26*	12.53*	0.25	19.87
Litter	14	6.42*	-2.60	-3.95*	3.27*	
Rock	14	-0.97	1.85	-1.47*	1.19*	
Annual grasses						
Bromus tectorum	6	-5.42*	1.60	-5.65*	0.74*	1.61
Festuca octoflora		-	-	-1.20	-0.49	0.57
Annual Forbs						
Collinsia parviflora	12	1.85*	0.45*	2.06*	0.34*	1.57
Descurainia sp.	7	3.46*	0.21	3.68*	0.08	3.56*
Phacelia linearis	9	5.93*	0.83*	8.46*	0.89*	6.29*
Salsola kali	2	0.00	-0.31	-	-	-0.38
Stellaria jamesiana	2	3.25	1.00	2.78	0.33	1.22
Perennial grasses & grasslikes						
Agropyron spicatum	8	0.14	4.25	-2.73*	4.21*	-4.16*
Calamagrostis rubescens	4	0.38	19.66*	14.42*	26.79*	-2.96
Carex geyeri	3	-0.21	0	-	-	0.29
Festuca idahoensis	10	-2.99*	3.49	-1.73*	7.36*	-8.28*
Poa sandbergii	8	-3.23*	0.58	1.09*	1.83	0.53
Poa sp.	6	0.40	2.77	-2.10*	0.85	-5.15*
Perennial forbs						
Achillea millefolium	10	-0.86	2.94	-0.99*	2.28*	-0.46
Agoseris glauca	5	0.03	-0.75	0.14	-0.14	-0.32
Anaphalis margaritacea	3	2.96	-0.50	2.32	-0.13	1.67
Antennaria microphylla	2	0.06	-1.06	0.06	-1.06	0
Antennaria racemosa	3	0	-0.13	0	-1.48	-0.19
Arabis sp.	4	-0.34	0	-0.52*	0	0.34
Arenaria conasta	8	1.45*	1.77*	1.79*	2.02*	-0.74
Arenaria aculeata	4	-0.78*	0.03	-0.03	-0.08*	0.92
Arnica cordifolia	6	3.38*	0.58	-1.09*	-4.23*	0.50
Arnica sororia	2	1.44	1.94*	4.41	0.90	0.41
Astragalus filipes	2	1.40	2.71*	1.45	2.94*	3.00*
Balsamorhiza hookeri	4	0.47	5.03	0.62	4.94*	7.38*
Castilleja sp.	2	0.00	-0.50	-	-	-0.50
Cerastium arvense	2	-15.31	0.00	-0.14	0	15.32

Table 2, Continued.

Species	Number Paired Plots	Percent Mean Difference 1980-81 Burned	1980-81 Unburned	1980-82 Burned	1980-82 Unburned	1980
Perennial forbs, continued						
Chenopodium leptophyllum	4	0.01	0			0.13
Crepis sp.	6	0.08	0.35	-0.65*	0.35	0.93
Epilobium angustifolium	6	1.40	0.17	2.21*	0	-5.55*
Eriogonum heracleoides	5	-0.40	0.50	-1.01	-0.08	-0.93
Eriogoneum ovalifolium	2	0.13	0.25	0.14	0.13	0.19
Frageria vesca	4	-0.09	14.84	-0.57	13.46*	-8.66
Gallium triflorum	2	0.31	0.69	0.29	-0.93	0.37
Geum triflorum	6	-0.98*	-0.04	-0.99*	-0.03*	1.32*
Lithophragma parviflora	2	1.00	1.06	-0.28*	0.38	0.46
Lomatium sp.	4	0.38	0.03			0.23
Lomatium triternatum	7	-0.18*	0.13	-0.41*	0.01	-0.27
Penstemon sp.	6	0.40*	-0.04			0.28
Sedum lanceolatum	3	0	0.46			-0.63
Sedum sp.	2	-0.06	0.75	0	-1.15*	-0.63
Senecio integerrimus						-5.44*
Taraxacum officinale	3	-0.08	-0.08	-1.20*	-0.11*	-0.13
Tragopogon dubius	7	1.25	1.66	1.64	0.33*	-0.13
Trifolium dasyphyllum	6	5.65	11.94*	9.32*	9.32*	5.86

Milkvetch (Astragalus filipes), chenopodium (Chenopodium sp.), fireweed (Epilobium angostifolium), avens (Geum triflorum), clover (Trifolium dasyphyllum), and starry cerastium (Cerastium arvense) all increased in canopy coverage as a result of the burn. Chenopodium was found only on burned sites. Fireweed and clover increased in coverage rapidly the first year after the burn, then gradually decreased the following growing seasons.

Cheatgrass (Bromus tectorum) and sixweeks fescue (Festuca octoflora) were the only annual grasses found in the study area. Both species increased as a result of the fire with cheatgrass being the more prevalent. Cheatgrass rapidly increased its canopy coverage on burned sites in 1980 and 1981, then continued to gradually increase in 1982.

The perennial grass generally declined as a result of the fire. Bluebunch wheatgrass, Idaho fescue, and bluegrass (Poa sp.) were the most notable decreasers. The decline in canopy coverage was immediate with 1980 being the low point, then gradual increases in coverage were observed for 1981 and 1982.

Canopy coverage of Sandberg bluegrass (Poa sandbergii) decreased on burned sites the first year after the fire, then returned to similar coverage on both burned and unburned sites the second growing season after the fire.

Herbaceous Production

Productivity of annual forbs, annual grasses, perennial forbs, perennial grasses, bluebunch wheatgrass, and Idaho fescue was measured in 1980 and 1981 (Table 3). Productivity of annual grass was higher on

Table 3. Comparison of productivity of herbaceous vegetation on burned and unburned sites, 1980 and 1981. Asterisk (*) indicates statistical significance at p = 0.05. Fourteen sites were sampled each year.

Group or Species	Year	Mean Difference Burned or Unburned (g/m^2) ± S.E.
Annual grasses	1980	0.1 ± 0.6
	1981	8.1 ± 6.2
Perennial grasses	1980	0.4 ± 3.0
	1981	15.4 ± 8.7*
Annual forbs	1980	8.4 ± 3.0*
	1981	7.4 ± 3.9*
Perennial forbs	1980	8.4 ± 5.1
	1981	-0.6 ± 4.0
Agropyron spicatum	1980	-4.9 ± 4.3
	1981	-7.6 ±12.3
Festuca idahoensis	1980	-7.8 ± 3.5*
	1981	-5.3 ± 4.3

burned sites the second year but not the first year. Variation between sites was high enough to keep differences at $p = 0.109$, below the assigned level of significance. Productivity of perennial grasses, excluding bluebunch wheatgrass and Idaho fescue, showed similar trends with the difference being significant the second growing season. Productivity of annual forbs increased significantly on burned sites both years, but perennial forbs did not.

Productivity of bluebunch wheatgrass averaged 6.3 gms per square meter less on burned sites than on adjacent unburned sites. Idaho fescue also showed declines in productivity on burned sites, decreasing an average of 6.6 g/m^2.

Heights of seed stalks of bluebunch wheatgrass and Idaho fescue were measured as an index of plant vigor (Table 4). Annual variation attributable to difference in rainfall patterns was apparent. Reductions in seed stalk height of both species the first growing season after the fire were significant. While significant differences in seed stalk heights of bluebunch wheatgrass on burned and unburned sites were apparent the second and third growing seasons, the actual differences were not considered large enough to be real. Similar variation occurred with Idaho fescue, although heights on burned sites were higher the second year.

Basal diameter measurements were highly variable, but generally were lower on burned sites. Bluebunch wheatgrass diameters were more affected than Idaho fescue. Average diameters on unburned sites were 9.2 cm and on burned sites were 5.9 cm for bluebunch wheatgrass plants. Idaho fescue plants averaged 4.7 cm on unburned sites and 4.3 on burned sites. These differences were significant but once again of little consequence for Idaho fescue.

Table 4. Heights of seed stalks of bluebunch wheatgrass and Idaho fescue on burned and unburned sites; 1980, 1981, 1982. * indicates difference between burned and unburned where significant at p = 0.05.

Species	Year	Number Plants Sampled	Stalk height (cm) Burned $\bar{X}$	± S.E.	Unburned $\bar{X}$	± S.E.
Bluebunch wheatgrass	1980	400	22.9*	0.25	26.5	0.25
	1981	400	74.0	0.67	74.9	0.62
	1982	300	63.8*	0.59	66.2	0.56
Idaho fescue	1980	300	17.0*	0.63	22.1	0.32
	1981	300	77.5*	0.66	68.2	0.84
	1982	300	52.3*	0.95	53.4	0.85

Shrubs

Curlleaf mountain-mahogany was a dominant shrub on the unburned winter ranges frequented by bighorn sheep in the study area (Table 5). The Ship Island Fire completely killed numerous mahogany stands in the area. During the three summer field seasons following the fire, no resprouting or seedling establishment of mountain mahogany was observed in the burned areas. Diameters of current growth and length of twigs did not vary significantly over a three year period on unburned sites (Table 7).

Shiny-leaf ceanothus and scouler willow appeared on burned sites in the summer of 1980, one year after the fire in Douglas fir areas. No evidence of rooted stems of either species could be found in the study area on either unburned or burned sites (Table 5). These seedlings were then counted as rooted stems on the burned sites in 1981 and 1982. Syringa (Philadelphus lewisi) seedlings were first observed two years following the fire.

Little greenbush was prevalent on the driest sites on the study area and was browsed extensively by bighorn sheep in winter. Little greenbush sprouted vigorously on burned sites and no significant difference in seedling or rooted stem densities between burned and unburned sites was demonstrated (Table 5). Height, stem diameter, canopy area, and twig number were all significantly reduced following burning (Table 6). Heights on burned sites remained at about half the heights of plants on unburned sites over the three year period after the burn. Canopy areas on burned sites remained at approximately 10% of the canopy areas on unburned sites over the three year period. Fewer twigs were available on burned sites, but a significantly greater proportion of the twigs available were

Table 5. Comparisons of rooted stems and seedlings per 10 m^2 of curlleaf mountain mahogany, little greenbush, shiney-leaf ceanothus and Scouler willow on burned and adjacent unburned sites, for the first and second growing seasons combined following the Ship Island Fire. Asterisk (*) indicates significant differences between burned and unburned sites at $p = 0.05$.

Species	Condition	Number of Sites	Rooted Stems per 10 m^2 $\bar{X}$ ± S.D.		Number of Sites	Number of seedlings per 10 m^2 $\bar{X}$ ± S.D.	
Mountain mahogany	burned	21	0.000	-	21	0.000	0.717
	unburned		0.429	0.447		0.329	0.080
Little greenbush	burned	21	1.320	2.010	21	0.020	0.080
	unburned		1.200	1.780		0.000	-
Shiney-leaf ceanothus	burned	2	1.700	2.120	3	2.230	3.780
	unburned		0.000	-		0.000	-
Scouler willow	burned	5	9.320*	3.100	9	7.530	10.020
	unburned		0.000	-		0.000	-

Table 6. Height, stem diameter, canopy area, twig numbers and twigs browsed of little greenbush on burned and unburned sites, 1980, 1981 and 1982; first, second and third years following the burn. Asterisk (*) indicates significant differences between burned and unburned sites.

		Height (cm)			Canopy area (cm^2)			Twig number/m^2			Percent Twigs
Year	Condition	N	$\bar{X}$	S.D.	N	$\bar{X}$	S.D.	N	$\bar{X}$	S.D.	Browsed
1980	Burned	47	15.7*	8.0	47	536.7*	1753.2	47	64.2*	70.5	-
	Unburned	48	39.5	16.5	48	5721.5	6572.9	48	1116.9	1021.5	-
1981	Burned	87	18.6*	7.8	87	458.8*	1032.6	87	234.1*	397.6	0.18*
	Unburned	88	48.7	21.2	88	7800.5	7087.1	88	1395.7	1138.9	0.03
1982	Burned	48	20.2*	10.5	48	431.3*	509.1	48	97.8*	96.7	0.35*
	Unburned	24	43.9	12.9	24	6182.7	5393.8	24	1428.7	964.7	0.21

browsed on the resprouting plants than on unburned areas.

Twigs of little greenbush grew more vigorously on burned sites than on unburned sites. Basal diameter of the twigs increased an average of 10% following burning (Table 7). Twig length also increased significantly showing a 55% increase on the average following burning.

Comparison of use of burned and unburned areas by bighorn

A total of 275 observations of bighorn sheep groups provided information on winter use of habitats within the perimeter of the fire (Table 8). Idaho Department of Fish and Game flights from 1974-1978, prior to the fire, showed that 84% of the observations of bands of bighorn were on sites that were subsequently burned. Following the fire, 66% of the observations were on sites that had been burned, a significantly lower percentage. The series of aerial flights done monthly over the 1980-1982 period showed 86% of the observations were in the burned area. Since 85% of the area within the burn perimeter was burned, bighorn showed no selection for or against burned areas. The patchiness of the fire, plus the previously established habitat use patterns likely overrode any apparent selection for burned or unburned areas.

Population response of bighorn to the fire

Bighorn populations were observed once annually from helicopter by Idaho Department of Fish and Game personnel from 1974-1984, excluding 1983 (Table 9). An average of 83 bighorns were observed over this period, no detectable trend in numbers. Fluctuations in population size were attributable to variation in snow cover, time of winter, and other weather

Table 7. Diameters at proximal end of current growth (DCG) and lengths of current growth of mountain mahogany on unburned sites and of little greenbush on burned and unburned sites, for the first three growing seasons following the fire. Asterisk (*) indicates differences between burned and unburned sites were significant at $p = 0.05$.

Species		Year	DCG (mm) N	DCG (mm) $\bar{X}$	DCG (mm) S.D.	Length (mm) N	Length (mm) $\bar{X}$	Length (mm) S.D.
Mountain mahogany (unburned sites only)		1980	45	1.98	0.44	45	72.8	19.8
		1981	49	2.31	0.36	49	76.4	20.8
		1982	24	1.76	0.35	24	67.7	14.9
Little greenbush	Burned	1980	41	1.50*	0.47	41	101.9*	48.5
	Unburned	1980	36	1.26	0.22	36	49.2	14.6
	Burned	1981	48	1.51	0.30	48	66.1*	23.8
	Unburned	1981	46	1.41	0.27	46	52.3	14.5
	Burned	1982	24	1.42	0.32	24	57.9*	19.9
	Unburned	1982	24	1.28	0.25	24	42.8	12.1

Table 8. Observations of bighorn sheep on burned and unburned sites within the perimeter of the Ship Island Burn. Data include observations by W. O. Hickey,[1] Idaho Department Fish and Game (IFG), 1979-1984. Observations prior to the fire listed as on burned sites were in those sites subsequently burned.

		Groups Seen Number	Groups on Burned Sites Number	Percent	Groups on Unburned Sites Number	Percent
IFG	1974-1978	55	46	84	9	16
IFG	1979-1983	44	29	66	15	34
This Study	1980-1982	176	152	86	24	14

[1]These data are on file at Salmon office, Idaho Department Fish and Game.

Table 9. Observations of bighorn sheep from 1974-1984 from helicopter surveys done by W. O. Hickey, Idaho Department of Fish and Game, Ship Island Burn. Data include areas within the perimeter of the burn only.

Period	Adult Ewes	Yearly Ewes	Lambs	Yearly Rams	Adult Rams	Total
1974 February	31	0	21	2	27	81
1975 March	41	6	18	6	23	94
1976 March	35	11	22	10	15	93
1977 March	39	8	14	5	23	89
1978 February	43	1	27	6	6	83
1979 April	27	0	8	4	16	55
1980 January	44	1	3	1	25	83
1981 February	39	0	6	7	13	65
1982 February	30	0	14	0	23	67
1984 March	65	0	28	2	15	117

variables which affect visibility of bighorn and their distributions. Flights in March showed highest numbers, likely because bighorn were visible on exposed slopes at low elevations where spring greenup of forage was in progress.

The observations of individual sex and age groups were also highly variable. No significant trend in numbers of adult ewes was apparent. Lamb ewe ratios have fluctuated from 7:100 to 68:100 over the ten year period on the burn, similar to fluctuations of bighorn immediately west of the burn on Stoddard Creek, and elsewhere on the Middle Fork drainage (Table 10). Sex ratios have also been comparable across the whole Middle Fork drainage.

Mean group sizes for bighorn observed on the Burn were significantly smaller than on adjacent unburned areas. Group sizes appeared to be smaller on the Burn after the fire than before (Table 11). These differences were significant, and may be related to the more limited forage base on the burned area.

Table 10. Comparison of lamb:adult ewes ratios and sex ratios of adult bighorn on the Ship Island Burn, Stoddard Creek (across the Middle Fork from Ship Island Burn), and the Middle Fork Salmon River drainage (excluding the Ship Island Burn Study Area). Data were taken from helicopter surveys by W. O. Hickey, Idaho Department of Fish and Game. Totals include yearling ewes and rams.

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1984
Ship Island Burn										
Total sheep observed	98	102	124	78	101	64	60	89	85	117
Rams	30	21	15	23	6	24	25	13	24	15
Ewes	39	46	46	32	53	27	31	57	41	65
Lambs	27	22	34	10	34	9	2	11	16	28
Lambs/100 ewes	68	44	63	36	63	30	7	15	47	43
Rams/100 ewes	87	56	43	59	14	59	57	33	77	23
Stoddard Creek										
Total sheep observed	162	220	159	148	124	140	136	140	151	-
Rams	31	38	10	25	16	17	39	41	30	-
Ewes	82	100	81	73	52	72	81	66	72	-
Lambs	41	70	31	33	38	31	6	29	24	-
Lambs/100 ewes	50	70	38	45	73	43	7	44	33	-
Rams/100 ewes	38	38	12	34	31	24	48	62	42	-
Middle Fork Salmon										
Total sheep observed										
Rams	120	133	84	81	95	64	131	-	120	-
Ewes	239	257	234	202	214	226	268	-	285	-
Lambs	125	139	102	96	166	81	32	-	138	-
Lambs/100 ewes	52	54	44	48	78	36	12	-	48	-
Rams/100 ewes	50	52	36	40	44	28	49	-	42	-

Table 11. Mean sizes of groups of bighorn sheep on burned and unburned areas within the Ship Island Study Area, and also before and after the fire. Pre-burn data were provided by W. O. Hickey, Idaho Department of Fish and Game, and include information from 1974-1979.

	Burn		Unburned	
Year	# obs	$\bar{X}$ group Size	# obs	$\bar{X}$ group Size
1974-79 (preburn)	29	4.7	37	4.9
1980	5	3.0	4	4.3
1981	2	1.5	5	11.2
1982	10	4.2	3	6.0
1980-1982	17	3.5	39	6.5

Discussion

Herbaceous plant response to the hot August fire was similar to that observed in comparable communities elsewhere (Blaisdell 1953, Mueggler and Blaisdell 1958, Conrad and Poulton 1966, Uresk et al 1976, Ralph and Busby 1979, Peek et al. 1979, Merrill et al. 1980, Johnson and Strang 1983, Britton et al. 1983). Perennial bunchgrasses are usually adversely affected for the shorter term and then show increased productivity for a few years after the initial adverse effect. Perennial forbs are usually less adversely affected initially, and again demonstrate increased productivity for a few years. The initial high increases in annual forbs and grasses are also commonly observed.

Increased sprouting and seedling densities of shiny-leaf ceanothus and Scouler willow were also expected after the fire (Lyon 1971, Mueggler 1965, Irwin and Peek 1979). Scouler willow appeared to be more prevalent than shiny-leaf ceanothus on this area, which is drier than the areas in the cedar-hemlock zone studied by Mueggler 1965 and Irwin and Peek (1979). Shiny-leaf ceanothus seedlings came in rapidly on the Neal Canyon Burn in Douglas fir habitat types, and increased to dominate the shrub by the sixth year after that burn (Lyon 1971). A similar pattern would likely prevail on Douglas fir sites on the Ship Island fire where shiny-leaf ceanothus establishes.

Little greenbush resprouted vigorously after the burn. Little is known of the autecology of this species, but it is a palatable forage for big game and occurs on severe sites where it is available during winter. Some seedling establishment was apparent on burned areas, but the

resprouting characteristic appeared to be the most important response to the fire by this species.

Mountain mahogany is known to be a non-resprouter and was killed by this fire as expected. This species is a major forage source for bighorn and other big game in the area (Smith 1954), and is ordinarily available during winter because of its height. The loss of this species as a forage source is a temporary deterioration of bighorn habitat attributable to the fire. However, the species likely will reestablish on sites where it is part of the vegetative complex, and the timing of this establishment should be noted.

Population response by bighorn to wildlife and to prescribed fire is highly variable (Peek et al. 1984). Several factors are likely attributable to the lack of any appreciable population response by bighorn to the fire. First, the area occurs in a region of high fire frequency which implies that, generally, bighorn have evolved with fire over evolutionary time. Specifically, sufficient area was likely left unburned for sheep to graze on the winter following the fire, and subsequently the regenerating vegetation was sufficient to accomodate the population.

Sampling error and sampling intensity also account for some unknown effect on the information obtained. The area is very inaccessible, so ground work was affected. The visibility of bighorn from the air was likely highly variable, depending on ground and weather conditions.

The small decline in group size indicates that the population was affected, but not at a level which the aerial observations of numbers, sex, and age could detect. If the conclusion of Shannon et al. (1975) that group sizes are related inversely to forage availability applies,

then the decline may reflect a temporary reduction in available forage diet occurred following the burn. Nevertheless, this decline was of negligible effect.

The Ship Island Burn must be considered as a severe case of fire affecting bighorn in this area, in as much as over three fourths of the known range of the sheep population was affected. If a population response was likely in this area, most certainly the Ship Island Fire offered a substantial example to evaluate. The fact that the bighorn population did not respond appreciably suggests that fire management programs, when established for the FCRWR, will not cause appreciable changes in populations of this important big game species.

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Appendix I. Listing of sites where herbaceous data were collected, and information from 1980, the first growing season after the Ship Island Fire.

	Pair		Pair		Pair		Pair	
Site Number	1	3	2	4	5	6	7	10
Unburned/Burned	UB	B	UB	B	UB	B	UB	B
Cover Type	Cele/Feid/Agsp		Cele/Feid/Agsp		D-F/Feid/Agsp		D-F/Feid/Agsp	
Elevation (ft)	3800	3900	3900	3900	4000	3900	5000	5000
Slope (%)	45	65	60	65	50	50	55	55
Aspect	NW	NW	NW	NW	W	W	W	WNW
Species	Can Cov/Freq	Can Cov/Freq	Can Cov/Freq	Can Cov/Freq	Can Cov/Freq	Can Cov/Freq	Can Cov/Freq	Can Cov/Freq
Achillea millefolium					8.7/35		4.5/55	4.6/20
Agoseris glauca	.37/15		1/15				.3/10	2.5/50
Anaphalis margaritacea								4.3/45
Antennaria microphylla								
Antennaria racemosa								
Arabis sp.								
Arenaria sp. 1	2.25/40	1.9/25	3.5/40	.87/10	5.6/75	5.25/60	4.0/60	5.1/55
Arenaria sp. 2								.9/10
Arenaria sp. 3								31.3/90
Arnica cordifolia						6.125/5		
Astragalus filipes	3.125/5		1.87/5	1.8/5	6.1/30		1.1/20	
Astragalus purshii					.12/5			
Balsamorhiza incana							3.1/50	13.3/70
Balsamorhiza hookeri							18.3.85	
Chenopodium leptophyllum		.12/5		.12/5				
Collinsia parviflora	.62/25	2.25/65	.25/10	1.6/40			1.8/45	6.5/85
Coryphantha vivipara					.37/15		2.1/60	
Crepis sp.		.75/5			5.6/80		1.6/15	13.3/70
Descurainia sp.		6.1/30		7.1/25		.125/5	.9/35	4.4/55
Epilobium angustifolium								
Eriogonum heracleoides							2.6/10	.8/5
Eriogonum ovalifolium					.37/15	.75/5		
Fragaria vesa								
Galium triflorum	2.25/20			2.8/20				
Geum triflorum								5.9/40
Lithophragma parviflora								2.3/40
Lomatium sp.					.5/20	.25/10		
Lomatium triternatum			.37/13	.125/5				
Mertensia longiflora								1.0/15
Mitella stauropetala								
Penstemon sp.					.25/10		.1/5	
Phacelia linearis	.25/10	15.75/75	.25/10	17.75/85	11/100	.125/5	3.0/70	
Salsola kali								
Sedum lanceolatum							.3/10	
Sedum sp.								
Senecio integerrimus								
Stellaria jamesiana								
Taraxacum officinale								
Tragopogon dubius							1.5/10	
Trifolium dasyphyllum							44.8/60	49.9/90
Unknown forb					.12/5	.375/15		
Agropyron spicatum	5.5/25	1.9/5	19.1/55	8.1/40	6.75/50	4.25/25	16.1/90	16.8/55
Bromus tectorum	.125/5			4.87/25	.125/5			
Calamagrostis rubescens								
Carex geyeri								
Festuca idahoensis	23.37/95	4/35	24.1/80	1.5/10	11.7/85	27.13/95	9.5/80	12.1/75
Festuca octoflora						.125/5		
Poa sandbergii	6.25/75		4.7/65	6/70	4.37/100	3.12/50	2.9/20	.8/30
Poa sp.		4.1/40		1.5/10			9.8/70	.6/25
Bare ground	3.8/65	58.1/100	.75/30	66.62/100	43.1/100	12.63/100	5.63/35	7.5/60
Litter	87.6/100	11.62/75	80.1/100	9.1/100	24.7/100	64.25/100	84.9/100	81.3/100
Rock	4.5/60	5.5/75	13.9/75	13.7/75	5.1/80	6.62/75	3.88/35	6.6/50

	Pair		Pair		Pair		Pair	
Site Number	8	9	15	11	16	12	14	13
Unburned/Burned	UB	B	UB	B	UB	B	UB	B
Cover Type	D-F/Feid/Agsp		Cele/Agsp		Cele/Agsp		D-F/Feid/Agsp	
Elevation (ft)	5000	5000	4000	6000	4000	5900	3400	3500
Slope (%)	55	60	55	80	45	75	65	65
Aspect	W	WNW	SSW	S	S	SSW	WNW	WNW
Species	Can Cov/Freq	Can Cov/Freq	Can Cov/Freq	Can Cov/Freq	Can Cov/Freq	Can Cov/Freq	Can Cov/Freq	Can Cov/Freq
Achillea millefolium	29.1/95	5.1/35				.9/10	2.8/15	3.5/25
Agoseris glauca	.6/25	1.4/30					.4/15	.6/25
Anaphalis margaritacea		7.8/20						
Antennaria microphylla								.1/5
Antennaria racemosa		.1/5						
Arabis sp.	.1/5							
Arenaria sp. 1	4.4/50	1.8/45		4.3/75	.1/5	4.0/35	4.8/90	.8/30
Arenaria sp. 2								
Arenaria sp. 3		2.5/25						
Arnica cordifolia								
Astragalus filipes	8.9/40						3.6/25	.4/15
Astragalus purshii								
Balsamorhiza incana	3.9/55	6.4/80						
Balsamorhiza hookeri	12.9/60			3.8/10				
Chenopodium leptophyllum								
Collinsia parviflora	2.0/55	5.8/85		2.9/65	.4/15	11.5/95	1.1/45	5.3/85
Coryphantha vivipara								
Crepis sp.	.9/10	3.5/40						.9/10
Descurainia sp.	1.0/15	1.1/20	.1/5	7.3/75	.6/24	6.3/55		
Epilobium angustifolium								
Eriogonum heracleoides	2.9/20				.1/5		.9/10	.9/35
Eriogonum ovalifolium							.5/20	
Fragaria vesa								
Galium triflorum								
Geum triflorum		1.0/15						
Lithophragma parviflora	3.4/35	2.0/55						
Lomatium sp.		.3/10				1.0/15		.1/5
Lomatium triternatum							.1/5	
Mertensia longiflora		.1/5						
Mitella stauropetala								
Penstemon sp.				.3/10				.8/5
Phacelia linearis	4.3/70		.4/15	7.3/90	1.0/15	13.9/95		7.6/65
Salsola kali			.1/5		.1/5			
Scdum lanccolatum								
Sedum sp.								
Senecio integerrimus							6.0/25	
Stellaria jamesiana								
Taraxacum officinale		.1/5						
Tragopogon dubius	.8/5			.1/5				
Trifolium dasyphyllum	20.9/30	51/100						
Unknown forb								.1/5
Agropyron spicatum	28.6/75	12.0/75	14.1/65	11.6/80	30.4/65	9.5/50	6.3/60	5.8/60
Bromus tectorum		10.8/65	.3/10	7.8/65	.5/20			
Calamagrostic rubescens								
Carex geyeri								
Festuca idahoensis	27.1/90	8.4/70		1.5/10			21.9/100	7.9/90
Festuca octoflora								
Poa sandbergii	7.5/75	.1/5		1.0/15		.5/20	3.0/70	3.0/70
Poa sp.	6.5/45	1.5/35				.3/10		
Bare ground	4.9/70	4.3/45	16.3/55	28/100	12.8/55	17/100	4.3/70	18.3/90
Litter	89/100	83/100	34.9/70	5/100	28.1/80	6.8/100	87.1/100	40.3/95
Rock	1/15	5.3/40	39.3/75	43.8/90	44.5/95	57.8/100	3.6/70	19.5/90

	Pair		Pair		Pair		Pair	
Site Number	20	17	19	18	22	21	24	23
Unburned/Burned	UB	B	UB	B	UB	B	UB	B
Cover Type	D-F/Phma/Caru		D-F/Phma/Caru		D-F/Caru		D-F/Caru	
Elevation (ft)	5500	5500	5500	5500	6100	6000	6200	6200
Slope (%)	55	60	70	55	55	65	60	50
Aspect	NNW	NW	N	N	NW	NW	WNW	NW
Species	Can Cov/Freq	Can Cov/Freq	Can Cov/Freq	Can Cov/Freq	Can Cov/Freq	Can Cov/Freq	Can Cov/Freq	Can Cov/Freq
Achillea millefolim	.1/5	.3/10					1.6/15	.8/5
Agoseris glauca								
Anaphalis margaritacea		1.3/50					.4/15	
Antennaria microphylla								
Antennaria racemosa								
Arabis sp.								
Arenaria sp.								
Arnica cordifolia	13.6/100	5.8/55	10.1/85	9.0/65	8.1/75	15.6/95	.4/15	9.3/70
Astragalus filipes								
Astragalus purshii								
Balsamorhiza incana								
Balsamorhiza hookeri								
Chenopodium leptophyllum								
Collinsia parviflora	.4/15	1.3/25	.1/5	.5/20	.3/10			.3/10
Coryphantha vivipara								
Crepis sp.								
Descurainia sp.								
Epilobium angustifolium		1.0/15		19.1/45		1.9/25		2.1/35
Eriogonum heracleoides								
Eriogonum ovafolium								
Fragaria vesa	7.8/85	2.1/35	8.1/60	4.9/25	6.3/35	2.5/25	6.5/40	.1/5
Galium triflorum								
Geum triflorum		.4/15						
Lithophragma parviflora								
Lomatium sp.								
Lomatium triternatum		.1/5			2.0/30			.1/5
Mertensia longiflora								
Mitella stauropetala								.1/5
Penstemon sp.								
Phacelia linearis								
Salsola kali								
Sedum lanceolatum					1.4/30			
Sedum sp.								
Senecio integerrimus								
Stellaria jamesiana					.3/10		2.0/10	3.8/30
Taraxacum officinale					.1/5			
Tragopogon dubius								
Trifolium dasyphyllum	10.3/90	21.6/75	8.5/90	10.3/30	45.4/100	40.1/85	30.8/95	34.4/70
Unknown forb		1.1/15		1.9/50				
Agropyron spicatum								
Bromus tectorum								
Calamagrostis rubescens	46.8/95	30.4/75	53.6/100	21.0/55	28.9/100	41.6/90	51.0/95	37.5/75
Carex geyeri						.1/5		
Festuca idahoensis		1.0/5			13.0/65		.3/10	.1/5
Festuca octoflora								
Poa sandbergii				.1/5				
Poa sp.					.3/10			
Bare ground	0/0	14.4/70	0/0	16.6/70	0/0	1.9/25	0/0	1.1/20
Litter	96.3/100	70.1/100	97.5/100	71.9/100	97.5/100	93.1/100	92.0/95	93.8/100
Rock	1.6/15	3.3/30	0/0	1.8/45	.1/5	1.6/40	5.5/30	3.5/40

	Pair		Pair					
Site Number	25	28	26	27				
Unburned/Burned	UB	B	UB	B				
Cover Type	Abla/Vasc		Abla/Vasc					
Elevation (ft)	7300	7200	7300	7300				
Slope (%)	40	43	44	38				
Aspect	N	NNW	N	NNW				
Species	Can Cov/Freq	Can Cov/Freq	Can Cov/Freq	Can Cov/Freq	Can Cov/Freq	Can Cov/Freq	Can Cov/Freq	Can Cov/Freq
Achillea millefolium								
Agoseris glauca								
Anaphalis margaritacea								
Antennaria microphylla								
Antennaria racemosa								
Arabis sp.								
Arenaria sp.								
Arnica cordifolia		1.6/40		.6/25				
Astragalus filipes								
Astragalus purshii								
Balsamorhiza incana								
Balsamorhiza hookeri								
Chenopodium leptophyllum								
Collinsia parviflora								
Coryphantha vivipara								
Crepis sp.								
Descurainia sp.								
Epilobium angustifolium		.8/5		.3/10				
Eriogonum heracleoides								
Eriogonum ovalifolium								
Fragaria vesa								
Galium triflorum								
Geum triflorum								
Lithophragma parviflora								
Lomatium sp.								
Lomatium triternatum								
Mertensia longiflora								
Mitella stauropetala								
Penstemon sp.		.1/5						
Phacelia linearis								
Salsola kali								
Sedum lanceolatum								
Sedum sp.								
Senecio integerrimus								
Stellario jamesiana								
Taraxacum officinale								
Tragopogon dubius								
Trifolium dasyphyllum								
Unknown forb								
Agropyron spicatum								
Bromus tectorum								
Calamagrostis rubescens								
Carex geyeri								
Festuca idahoensis								
Festuca octoflora								
Poa sandbergii								
Poa sp.								
Bare ground	32.4/100	1.0/40	63.6/100	.6/25				
Litter	27.6/100	95/100	3.3/55	88.9/100				
Rock	14.6/100	1.1/20	26.3/95	6.8/75				